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Amphispores of the grass and sedge rusts*

JOSEPH CHARLES ARTHUR

There is but one known exception (*Puccinia graminella*) to the general statement that all plant-rusts occurring on grasses and sedges possess in their life-cycle the full complement of spores characteristic of the *Uredineae*, *i. e.*, aecidiospores, uredospores and teleutospores. In the majority of cases knowledge of the cycle is yet incomplete, and the aecidiospores and sometimes the uredospores are yet to be detected and described, but there is no reason to doubt that they exist. All grass and sedge rusts belong to either the genus *Puccinia* or *Uromyces*.

Species of *Puccinia* often possess one-celled teleutospores, which are called mesospores. Such spores do not differ structurally or physiologically from the normal two-celled teleutospore of the species, except that the lower cell is wanting.

A few species, belonging to both *Puccinia* and *Uromyces*, possess two sorts of uredospores, which differ both structurally and physiologically, and in the most marked forms the divergence is very wide. A good, and in some ways the best illustration of the two forms of teleutospores and uredospores may be found in *Puccinia vexans*, a species of which Sydow † remarks in his monograph of the *Uredineae*, that here is presented the interesting fact of a *Puccinia* with two different teleutospores and two sorts of uredospores.

Uredospores in general serve the purpose of summer spores for the rapid dissemination of the species. Their walls do not protect the spore from much drying or great extremes of temperature. As soon as mature they drop away readily, and are free to be blown about by the wind.

The modified uredospores, to which the name amphispore was given by Carleton * in 1901, are on the contrary resting spores, and possess thick, indurated walls, colorless contents and persistent or semi-persistent pedicels. The sori appear to the naked eye, and under a hand lens, like those of the teleutospores, for which they are often mistaken. This mistake has, in a number of instances, led to their description as species of *Uromyces;* thus *U. Brandegei* Pk., *U. simulans* Pk., *U. scaber* E. & E., *U. Caricis* Pk., and *U. atrofusca* Dudl. & Th., are names of the amphisporic stages of different species of *Puccinia.* Amphispores can always be told from true teleutospores, however, by possessing two or more germ pores, while teleutospores have but one, and that is usually not discernible except at time of germination.

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* Read before the Indiana Academy of Sciences, at Indianapolis, Nov. 25, 1904.

† "So hätten wir die interessante Tatsache, dass eine *Puccinia* zwei verschiedene Teleutosporen und zweierlei *Uredosporen* hervorbringt." Sydow, Monog. Ured. 1: 736. 1904.

Amphispores appear to belong to species having their main development in arid or semi-arid regions. They give to the uredospore the same power to tide over unfavorable periods of growth that is usually possessed only by the teleutospore, and with the additional advantage that when the inhibiting period is past they can infect the same host from which they were derived, whereas the teleutospore can only infect an alternate host of a different species.

Up to the present time no species found to possess amphispores is known outside the United States and Mexico, with the single exception of an Indian species occurring in the Himalayas. Most of the collections have been made in the semi-arid regions of North America. Because this form of spore is not usually recognized, and not well understood, the writer presents the fol-fowing notes and illustrations, drawn from specimens in his herbarium.

1. PUCCINIA VEXANS Farl. (*Uromyces Brandegei* Pk.) has globoid uredospores with golden yellow, thin walls, minutely echinulate, and showing eight scattered germ pores. Their pale color makes them comparatively inconspicuous, moreover they are but sparingly produced, and in consequence but rarely collected.

The amphispores are much larger than the uredospores, obovate, semiopaque, and with dark chestnut-brown walls, very thick, much thicker above, densely verrucose, and possessing four germ pores which are symmetrically arranged in a circle just below the equator. The pedicels are long and persistent, and resemble those of the teleutospores. The sori look like the teleutosori. They sometimes have an intermixture of either uredospores or teleutospores, but more often are without either. They are the most abundant spore-form of the species. It is not yet known what are the favorable conditions for germination, and Carleton * is yet alone in a successful attempt to start them into growth. In a study of the evolution of this form the fact, that occasionally the usually smooth teleutospores show on their apical portion a verrucose sculpturing similar to that of the amphispores, will doubtless prove significant. The species ranges from Iowa and Nebraska to central Mexico.

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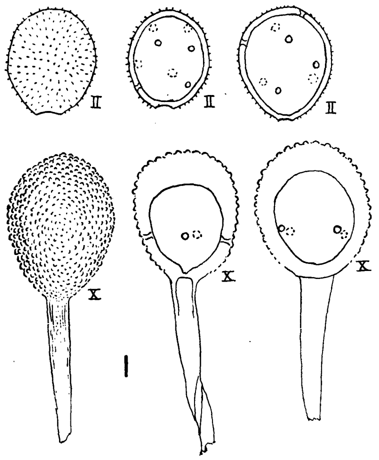
* Science II. 13 : 249.



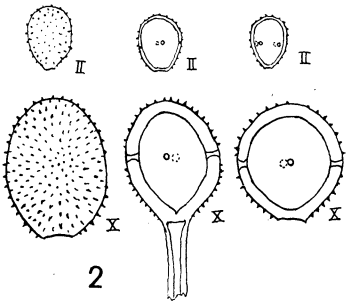


FIGURE 1. *Puccinia vexans* Farl.; on *Atheropogon curtipendulus*. Central United States and Mexico. II, Uresdopores. X, Amphispores.

FIGURE 2. *Puccinia Tripsaci* D. & H.; on *Tripsacum dactyloides*. Southern United States and Mexico. II, Uredospore. X, Amphispores.

2. PUCCINIA TRIPSACI D. & H. (*Uredo pallida* D. & H.) has remarkably small, very pale uredospores, with very thin, minutely verrucose-echinulate wall, having four equatorial pores. The sori appear white.

The amphispores resemble the uredospores in shape, echinulation and germ pores, but are immensely larger in every way. The wall is cinnamon-brown, and the sori are conspicuous. They occur in connection with the uredosori, teleutosori, or alone.

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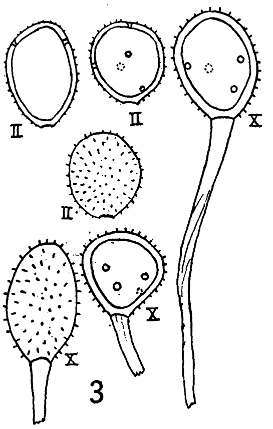
* Investigations of rusts. Bull. Bureau Pl. Ind. 63 : 23. 1904.

There is such a great difference between the two uredo forms that some mycologists are not willing to accept the relationship here claimed. Absolute proof can not be offered until cultures have been made. The species extends through central Mexico and northward into the United States.

3. PUCCINIA STIPAE Arth. (*Uredo Eriocomae* Ellis, *U. luxurians* E. & E., *Puccinia substerilis* E. & E., *P. micrantha* Griff.) has uredospores of the usual appearance, globoid, with rather thin, pale yellow walls, echinulate, with about six scattered germ pores. The sori are yellow and inconspicuous.



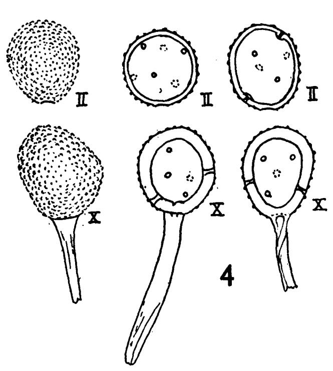


FIGURE 3. *Puccinia Stipae* Arth.; on *Stipa*, *Oryzopsis* and *Eriocoma*. Central United States and Mexico. II, Uredospores. X, Amphispores.

FIGURE 4. *Puccinia tosta* Arth.; on *Sporobolus airoides*, etc. Central United States. II, Uredospores. X, Amphispores.

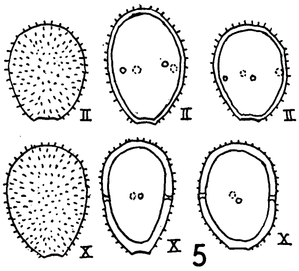
The amphispores have heretofore been considered the uredoform of a separate species, and have been called *Uredo luxurians* and *Puccinia substerilis.* They are about the same size as the uredospores, more inclined to be ellipsoid, with a much thicker, cinnamon-brown wall, strongly echinulate, and with pores similarly arranged. The pedicels are persistent, and often very long. The sori are dark brown, conspicuous, and have the appearance of teleutosori. Amphispores have been found on *Stipa viridula*, *S. Vaseyi* and *Eriocoma cuspidata.* The species ranges from Manitoba to New Mexico and Arizona.

4. PUCCINIA TOSTA Arth. (*Uromyces scaber* E. & E.) has

globose uredospores, with rather thin brownish yellow wall, finely verrucose, and with about six scattered germ pores.

The amphispores are similar, but with very much thicker walls, deeper colored, somewhat more coarsely verrucose, and with persistent pedicels. They are very rarely collected, and are only known to the writer from Colorado, on what is probably *Sporobolus airoides*. The type of *Uromyces scaber* was given as "an unknown grass," and has not been seen by the writer, but is clearly the amphisporic stage of this species. The species ranges from Montana and South Dakota to Texas and Arizona.

5. PUCCINIA CRYPTANDRI Ell. & Barth. (*Uromyces simulans* Pk.) rarely presents any other form of uredo than the amphispore. If the usual thin-walled uredospore does occur as a clearly marked form, it has been rarely collected. There is no collection of the species in the writer's herbarium gathered earlier in the season than the middle of August. Spores from a collection made August 21 are figured as the summer form of the spore. The walls are thin, and the spore appears paler and less firm than in collections made in October and November. The usual autumn collections have the characteristics of amphispores. The sori are dark cinnamon-brown, with apparently persistent spores, although in transferring them to the microscope they separate readily from the pedicels. The type of *Uromyces simulans* has been examined, and the amphisporic character of the spores is especially marked. Some experimental evidence that these are resting spores, and



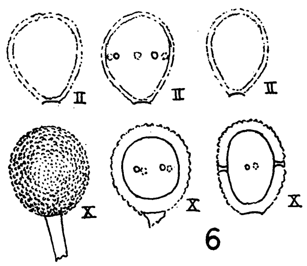
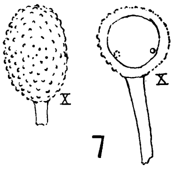


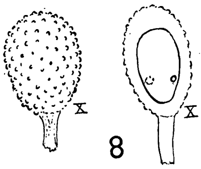
FIGURE 5. *Puccinia Cryptandri* E. & B.; on *Sporobolus cryptandrus*, etc. Central United States. II, Uredospores. X, Amphispores.

FIGURE 6. *Uromyces Rottboelliae* Arth.; on *Rottboellia speciosa*. Northern India, alt. 2100 m. II, Uredospores. X, Amphispores.

consequently amphispores, is afforded by the successful germination by Carleton * of spores that had lain in the herbarium a year. The distinction between summer uredospores and the resting form or amphispores in this species needs further study. The species ranges from Montana to Arizona, and as far east as Tennessee.

6. UROMYCES ROTTBOELLIAE Arth. was described from very limited material, and while characteristic teleutospores and amphispores were present, no specially good examples of true uredospores were seen. So far as could be judged the uredospores are thin-walled, and pale, but otherwise like the amphispores.





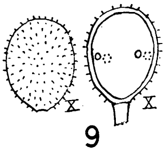


FIGURE 7. *Puccinia Caricis-strictae* Diet.; on *Carex stricta*. New York. X, Amphispores.

FIGURE 8. *Puccinia atrofusca* (D. & T.) Holw.; on *Carex Douglasii* and *C. usta*. Western coast of United States. X, Amphispores.

FIGURE 9. *Puccinia Garrettii* Arth.; on *Carex Hoodii*. Utah. X, Amphispores.

The amphisori are prominent and have the gross appearance of dark brown teleutosori. The spores are globoid, very thick-walled, finely verrucose, with four equatorial pores.

7. PUCCINIA CARICIS-STRICTAE Diet. (*Uromyces Caricis* Pk.) has been collected but once. It was found near Albany, N. Y., in October, 1876, and distributed in Thuemen's *Mycotheca universalis, no. 746,* and has not been met with since. To the naked eye the sori look like teleutosori. The spores have uniformly thick, dark brown walls, finely verrucose, with two pores, opposite and a little below the equator, and have colorless semipersistent pedicels. It seems impossible to find even stray uredospores of the summer form on the material of this collection. A few teleutospores occur, and on the evidence of these Dietel placed the species in the genus *Puccinia.*

8. PUCCINIA ATROFUSCA (D. & T.) Holw. (*Uromyces atrofuscus* Dudl. & Thomps.) is a western species recently found in Wash-

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* Bull. Bureau Pl. Ind. 63 : 21.

ington and California, on *Carex Douglasii* and *C. usta.* It closely resembles the preceding species, and like it shows no summer form of the uredospores, and only a few intermixed teleutospores. The amphispores are similar to the last in color, surface markings and pores, but they are a little larger and have the upper part of the wall decidedly thicker than the sides.

9. **Puccinia** (?) **Garrettii** n. sp. Two collections of this new form, obtained at Salt Lake City, Utah, on *Carex Hoodii* Boott, have recently been sent to me by A. O. Garrett: *no. 333*, Sept. 10, 1904, and *no. 614*, Oct. 11, 1904, the latter being taken as the type. The sori resemble teleutosori, but contain only amphispores. Not a single teleutospore could be found, and the species is referred to the genus *Puccinia* on the ground that most *Carex* rusts belong to it. Summer form of uredospores could not be found. The amphisori are amphigenous, scattered, oblong, chestnut-brown, slightly pulverulent; amphispores obovate or globoid, 21–26 by 27–35 μ, wall dark brown, rather thin, 1–1.5 μ, evenly echinulate, pores variable, 3–4, equatorial, pedicel colorless, semipersistent, one half to once length of spore. The species is notable in possessing the thinnest-walled amphispores yet known.

From the above descriptions and illustrations, which embrace all examples so far known, it will readily be seen that amphispores are the resting or winter form of uredospores. They are, however, no longer uredospores, accurately speaking, because they show distinct structural differences, often very great, and are correspondingly modified physiologically. They are clearly entitled to recognition as a distinct sort of spore.

PURDUE UNIVERSITY.